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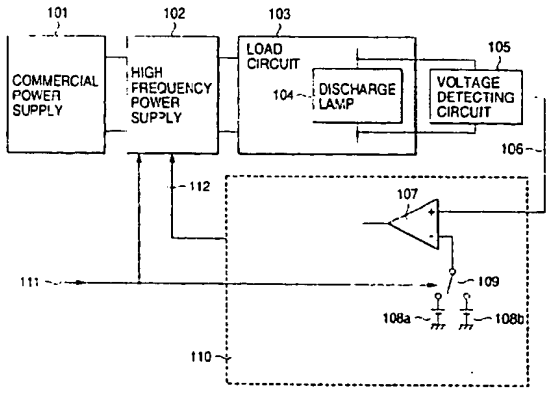
(54) Discharge lamp igniting apparatus

(57) When a light level of a discharge lamp (104) is smaller than or equal to a predetermined value, first and second reference voltage (108a,108b) are switched by a two-stage switching circuit (109). A comparator (107) compares a detection voltage (106) of the discharge lamp with the first reference voltage, or the detection voltage with the second reference voltage. When the voltage of the discharge lamp becomes high, a control circuit (110) supplies to a high frequency power supply (102), a control signal (112) for interrupting, or reducing an output of the high frequency power supply.

Accordingly, it is possible to more correctly discriminate the discharge lamp being operated under normal condition from the discharge lamp being operated in the final lifetime stage over the entire range of the light level. As a consequence, the discharge lamp can be used in the proper manner, and further the electrical damage of the discharge lamp igniting apparatus can be avoided in advance.

FIG. 5



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a discharge lamp igniting apparatus provided with a function for correctly judging a final lifetime stage of a discharge lamp.

2. Description of the Related Art

[0002] Fig. 1 is a structural diagram for explaining another conventional discharge lamp igniting apparatus described in, for instance, Japanese Laid-open Patent Application No. 64-3995. In the drawing, reference numeral 101 indicates the commercial power supply, reference numeral 102 denotes the high frequency power supply for converting the DC power converted by the rectifying/smoothing circuit 124 into the high frequency power, and reference numeral 103 indicates the load circuit containing the discharge lamp 104. Reference numeral 105 shows the voltage detecting circuit for detecting the voltage of the discharge lamp 104, reference numeral 106 indicates the detection voltage by the voltage detecting circuit 105 and reference numeral 110 represents the control circuit in which the comparator 107 compares the detection voltage 106 with the first reference voltage 108a and the control signal 112 is sent to the high frequency power supply 102.

[0003] Next, a description will be made of operation of the discharge lamp igniting apparatus with reference to Fig. 1 When the discharge lamp 104 reaches the final lifetime stage, the half wave discharge will occur in which a discharge occurs only from one electrode of the discharge lamp 104, and no discharge occurs from the other electrode thereof. When the half wave discharge occurs, since the impedance of the discharge lamp 104 is increased, a high voltage is produced from the voltage detecting circuit, as compared with that when the normal discharge occurs. The detection voltage 106 detected by the voltage detecting circuit 105 is compared with the first reference voltage 108a by the comparator 107 of the control circuit 110, and when the detection voltage 106 is higher than the first voltage, the control circuit judges that the discharge lamp is in the final lifetime stage. Then, the control circuit 110 sends the control signal for interrupting, or reducing the output of the high frequency power supply 102 in order to prevent the discharge lamp igniting apparatus from being destroyed.

[0004] Now, the operation characteristic while the discharge lamp 104 is turned ON is shown in Fig. 2. The discharge lamp 104 under turn-ON state owns the negative characteristic that the discharge voltage is gradually increased in connection with the decrease of the discharge current, as shown in Fig. 2. As a consequence, since the impedance of the discharge lamp 104 in the final lifetime stage is large, the discharge current becomes low. As a result, the voltage of the discharge lamp in the final lifetime stage is higher than that under normal turn-ON state.

[0005] Since the conventional discharge lamp igniting apparatus is arranged in the above described manner, in the discharge lamp igniting apparatus having no such a dimming control function for variably controlling the light flux emitted from the discharge lamp, either the voltage of the discharge lamp during the normal operation or the voltage of the discharge lamp during the final lifetime stage is produced from the voltage detecting circuit. as a consequence, in order to correctly judge the final stage of the discharge lamp, the first reference voltage to be set into the comparator is suitably located in the voltage region shown in Fig. 3.

[0006] However, in the discharge lamp igniting apparatus equipped with the dimming control function, as shown in the operation characteristic of Fig. 4, the voltage of the discharge lamp under normal condition is gradually increased in connection with the decrease of the light level with respect to the full light. As a result when the first reference voltage to be set to the comparator is set to, for example, a zone "A" of Fig. 4, namely, when the level of the first reference voltage is set to high, it could not correctly judge the final lifetime stage of the discharge lamp near the full light (light level: 10%). Thus, there is a risk that the discharge lamp igniting apparatus would be destroyed. Also, when the first reference voltage to be set to the comparator is set to a zone "B" of Fig. 4, namely when the level of the first reference voltage is set to low, there is a problem. That is, the discharge lamp operated under normal condition in the low dimming control range is erroneously judged as the discharge lamp operated in the final lifetime stage. As described above, it is very difficult to set the range of the first reference voltage.

SUMMARY OF THE INVENTION

[0007] The present invention has been made to solve the above described problem, and an object of the invention is to provide a discharge lamp igniting apparatus having a dimming control function and capable of not making an erroneous judgement such that a discharge lamp operable under normal state is recognized as that of a final lifetime stage, but also of correctly judging the final lifetime stage of the discharge lamp, whereby it is possible to prevent the discharge lamp igniting apparatus from being electrically destroyed.

[0008] To this end, a discharge lamp igniting apparatus according to a first aspect of the invention is featured by such a discharge lamp igniting apparatus arranged by a discharge lamp, and a high frequency power to this discharge lamp, for controlling an output of this high frequency power supply to control light of the discharge lamp, comprising: voltage detecting means for detecting a voltage of the discharge lamp; voltage changing means fo chang· ·g either the voltage of the discharge

lamp detected by this voltage detecting means or a reference voltage in response to a light level of the discharge lamp; comparing means for comparing the reference voltage with the voltage of the discharge lamp changed by this voltage changing means; and control means for interrupting the output of the high frequency power supply when the voltage of the discharge lamp becomes high.

[0009] Further, a discharge lamp igniting apparatus according to a second invention is featured by that the control means in the eleventh aspect to the invention includes two-stage switching means for switching a first reference voltage and a second reference voltage when the light level of the discharge lamp is lower than, or equal to a predetermined value; the comparing means compares the voltage of the discharge lamp with the first reference voltage, or the voltage of the discharge lamp with the second reference voltage; and when the voltage of the discharge lamp becomes high, the output of the high frequency power supply is interrupted, or reduced.

[0010] Further, a discharge lamp igniting apparatus according to a third aspect of the invention is featured by that the control means in the eleventh aspect of invention includes hysteresis means for establishing a hysteresis characteristic at a point where when the light level of the discharge lamp is smaller than equal to a predetermined value, the first reference voltage is switched into the second reference voltage by the two-stage switching means, and at another point where the second reference voltage is switched into the first reference voltage by the two-stage switching means; the comparing means compares the voltage of the discharge lamp with the first reference voltage, or the voltage of the discharge lamp with second reference voltage; and when the voltage of the discharge lamp becomes high, the output of the high frequency power supply is interrupted, or reduced.

[0011] Further, a discharge lamp igniting apparatus according to a fourth aspect of the invention is featured by that the control means in the eleventh aspect of the invention includes hysteresis means for establishing a hysteresis characteristic at a point where when the light level of the discharge lamp is smaller than, or equal to a predetermined value, plural-stage switching means switches the voltage from the first reference voltage into and further from the second reference voltage into a third reference voltage; and at another point where the plural-stage switching means switches the voltage from the third reference voltage to the second reference voltage and further from the second reference voltage to the first reference voltage; and the comparing means compares the voltage of the discharge-lamp with the first reference voltage, or the voltage of the discharge lamp with the second reference voltage, or the voltage of the discharge lamp with the third reference voltage; and when the voltage of the discharge lamp becomes high, the output of the high frequency power supply is interrupted, or reduced.

Further, a discharge lamp igniting apparatus according to a fifth aspect of the invention is featured by that the control means in the eleventh aspect of the invention includes voltage amplifying means for gradually amplifying the reference voltage in connection with the decrease of the light level of the discharge lamp; the comparing means compares the voltage of the discharge lamp with the voltage amplified by the voltage amplifying means; and the output of the high frequency power supply is interrupted, or reduced.

[0012] Further, a discharge lamp igniting apparatus according to a sixth aspect of the invention is featured by that the control means in the eleventh aspect of the invention includes voltage dividing means for dividing the voltage of the discharge lamp when the light level of the discharge lamp is smaller than, or equal to a predetermined value; the comparing means compares the voltage of the discharge lamp with the reference voltage, or the voltage divided by the voltage dividing means with the reference voltage; and when the voltage of the discharge lamp, or the voltage divided by the voltage dividing means becomes high, the output of the high frequency power supply is interrupted, or reduced.

[0013] Further, a discharge lamp igniting apparatus according to a seventh aspect of the invention is featured by that the voltage control means in the eleventh aspect of the invention includes voltage attenuating means for gradually attenuating the voltage of the discharge lamp in connection with the decrease of the light level of the discharge lamp; the comparing means compares the reference voltage with the voltage attenuated by the voltage attenuating means; and when the voltage attenuated by the voltage attenuating means become high, the output of the high frequency power supply is interrupted, or reduced.

[0014] Further, a discharge lamp igniting apparatus according to an eighth aspect of the invention is featured by that the control means in the eleventh aspect of the invention causes the comparing means to compare the voltage of the discharge lamp with the reference voltage when the light level of the discharge lamp is larger than, or equal to a predetermined value, and either interrupts or reduces the output of the high frequency power supply when the voltage of the discharge lamp becomes high.

[0015] The above and other objects and features of the present invention will be more apparent from the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016]

Fig. 1 is a structural diagram for describing another conventional discharge lamp igniting apparatus.

Fig. 2 is an example of an operation characteristic of a discharge lamp.

Fig. 3 is an example of the reference voltage setting range of the conventional discharge lamp igniting apparatus.

Fig. 4 is an example of the conventional operation characteristic.

Fig. 5 is a structural diagram for representing a discharge lamp igniting apparatus according to a first embodiment of the present invention.

Fig. 6 is an example of an operation characteristic according to the first embodiment.

Fig. 7 is a structural diagram for showing a second embodiment.

Fig. 8 is an example of an operation characteristic according to the second embodiment.

Fig. 9 is a structural diagram for representing a third embodiment.

Fig. 10 is an example of an operation characteristic according to the third embodiment.

Fig. 11 is a structural diagram for showing a fourth embodiment.

Fig. 12 is an example of an operation characteristic according to the fourth embodiment.

Fig. 13 is a structural diagram for representing a fifth embodiment.

Fig. 14 is an example of an operation characteristic according to the fifth embodiment.

Fig. 15 is a structural diagram for showing a sixth embodiment.

Fig. 16 is an example of an operation characteristic according to the sixth embodiment.

Fig. 17 is a structural diagram for responding a seventh embodiment.

Fig. 18 is an example of an operation characteristic according to the seventh embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0017] Now, a description will be given in more detail of preferred embodiments of the present invention with reference to the accompanying drawings.

[0018] It should be noted that the same reference numerals are employed as those for indicating the same or similar circuit elements.

(First Embodiment)

[0019] Fig. 5 is a diagram for explaining a discharge lamp igniting apparatus according to an embodiment of the present invention. In Fig. 5, reference numeral 101 shows a commercial power supply, reference numeral 102 represents a high frequency power supply, and reference numeral 103 denotes a load circuit containing a discharge lamp 104. reference numeral 105 shows a voltage detecting circuit for detecting a voltage of the discharge lamp 104, reference numeral 106 is a detection voltage detected by the voltage circuit 105, reference numeral 107 represents a comparator for comparing a first reference voltage 108a with the detection voltage 106, or the detection voltage 106 with a second reference voltage 108b, and reference numeral 109 shows a two-stage switching circuit for switching the first reference voltage 8a and the second reference voltage 108b. Reference numeral 110 indicates a control circuit for sending a control signal 112 to the high frequency power supply 102 in response to the output from the comparator 107, and reference numeral 111 represents a dimming control signal entered into the control circuit 110.

[0020] Referring now to Fig. 5, operations of the discharge lamp igniting apparatus according to the first embodiment will be explained. The voltage of the commercial power supply 101 is inputted into the high frequency power supply 102 to convert the voltage of the commercial frequency into a voltage of a high frequency. The voltage of the high frequency converted by the high frequency converted by the high frequency power supply 102 is controlled in response to an externally inputted dimming control signal 111, and then is entered into the load circuit 103. As a result, the discharge lamp 104 is turned ON, the voltage of the discharge lamp 104 is detected by the voltage detecting circuit 105, and then the detected voltage 106 is outputted from the voltage detecting circuit 105. These operations are similar to those of second to seventh embodiments which will be describe later. Subsequently, the comparator 107 for constituting the control circuit 110 compares detected voltage 106 outputted from the voltage detecting circuit 105 with the first reference voltage 108a which is switched by the two-stage switching circuit 109 in response to the dimming control signal 111, or compares the detected voltage 106 with the second reference voltage 108b which is switched by the two-stage switching circuit 109.

[0021] Then, when the detection voltage 106 becomes high, the comparator 107 judges that it is the discharge lamp 104 in the final lifetime stage, and sends a control signal 112 to the high frequency power supply 102, by which the output of the high frequency power supply 102 is interrupted, or reduced.

[0022] Then, operations of the discharge lamp igniting apparatus will now be explained with reference to a characteristic diagram shown in Fig. 6. Fig. 6 represents a relationship between a light level for full light and the detected voltage 106 of the discharge lamp 104 under normal condition, and another relationship between the light level for the full light and the reference voltage. When the light level with respect to the full light is smaller than, or equal to a predetermined value, the reference voltage to be set to the comparator 107 is switched by the two-stage switching circuit 109 from the first reference voltage 108a to the second reference voltage 108b, as shown in Fig. 6. It should be noted that the reference voltage owns the necessary condition, i.e., the first reference voltage 108a < the second reference voltage 108b. Then, when the detected voltage 106 reaches either the first reference voltage 108a or the second reference voltage 108b, it is judged that the discharge lamp 104 is in the final lifetime stage. This may be also applied to the second embodiment. As a consequence, the comparator 107 can perform such a correct judgement between the discharge lamp 104 under normal state and the discharge lamp 104 in the final lifetime stage over the entire range of the light level. As a consequence, the discharge lamp 104 can be properly used, and also it is possible to prevent the discharge lamp igniting apparatus from being destroyed.

(Second Embodiment)

[0023] Fig. 7 is a diagram for explaining a discharge lamp igniting apparatus according to a second embodiment of the present invention. In. Fig. 7, reference numeral 113 shows a hysteresis circuit for establishing a hysteresis characteristic when the two-stage switching circuit 109 switches the first reference voltage 108a and the second reference voltage 108b. It should be noted that the same reference numerals employed in the first embodiment are used to indicate the same or similar circuit elements of this embodiment.

[0024] Referring now to Fig. 7, operations of the discharge lamp igniting apparatus according to the second embodiment will be described. a dimming control signal 111 is entered into the hysteresis circuit 113 so as to establish hysteresis characteristics at a point where the reference voltage is switched from the first reference voltage 108a to the second reference voltage 108b by the two-stage switching circuit 109 in response to the dimming control signal 111, and at another point where the reference voltage is switched from the second reference voltage 108b into the first reference voltage 108a. Next, the comparator 107 for constituting the control circuit 110 compares the detected voltage 106 outputted from the voltage detecting circuit 105 with the first reference voltage 108a, or compares the detected voltage 106 with the second reference voltage 108b. then, when the detected voltage 106 becomes high, the comparator 107 judges that it is the discharge lamp 104 in the final lifetime stage, and sends a control signal 112 to the high frequency power supply 102, by which the output of the high frequency power supply 102 is interrupted, or reduced.

[0025] Then, operations of the discharge lamp igniting apparatus will now be explained with reference to a characteristic diagram shown in Fig. 8. Fig. 8 represents a relationship between a light level with respect to full light and the detection voltage 106 of the discharge lamp 104 under normal condition, and another relationship between the light level for the full light and reference voltage. When the light level for the full light is smaller than, or equal to a predetermined value, the hysteresis characteristics are established by the two-stage switching circuit 109 and the hysteresis circuit 113 at the point where the reference voltage to be set to the comparator 107 is switched from the first reference voltage 108a to be the second reference voltage 108b, and at the point where the reference voltage is changed from the second reference voltage to the first reference voltage, as indicated in Fig. 8. As a result, the first reference voltage 8a and the second reference voltage 108b and the second reference voltage 108b are stably switched by the two-stage switching circuit 109. Also, it is possible to prevent the two-stage switching circuit 109 from being very sensitively reacted in response to the extemally supplied noise. As a consequence, the comparator 107 can perform such a correct judgment between the discharge lamp 104 under normal state and the discharge lamp 104 in the final lifetime stage over the entire range of the light level. as a consequence, the discharge lamp 104 can be properly used, and also it is possible to prevent the discharge lamp igniting apparatus from being destroyed.

(Third Embodiment)

[0026] Fig. 9 is a diagram for explaining a discharge lamp igniting apparatus according to a further embodiment of the present invention. Fig. 9, reference numeral 114 denotes a three-stage switching circuit for switching the first reference voltage 108a, the second reference voltage 108b, and a third reference voltage 108c. It should be noted that the same reference numerals shown in the first and second embodiments will be employed as those for denoting the same or similar circuit elements in the third embodiment.

[0027] Operations of the discharge lamp igniting apparatus according to the third embodiment will now be described with reference to Fig. 9. The dimming control signal 111 is inputted into the hysteresis circuit 113, and a hysteresis characteristic is established at a point where the reference voltage is switched from the first reference voltage 108a to the second reference voltage 108b by the three-stage switching circuit 114 and further from the second reference voltage 108b to the third reference voltage 108c in response to the dimming control signal 111, and another point where the reference volt-

age is switched from the third reference voltage 108c to the second reference voltage 108b, and further from the second reference voltage 108b to the first reference voltage 108a. Next, the comparator 107 for constituting the control circuit 110 compares the detected voltage 106 outputted from the voltage detecting circuit 105 with the first reference voltage 108a, or the detected voltage 106 with the second reference voltage 108b, or the detected voltage 106 with the third reference voltage 108c. Then, when the detected voltage 106 becomes high, the comparator 107 judges that it is the discharge lamp 104 in the final lifetime stage, and sends a control signal 112 to the high frequency power supply 102, by which the output of the high frequency power supply 102 is interrupted , or reduced.

[0028] Then, operations of the discharge lamp igniting apparatus will now be explained with reference to a characteristic diagram shown in Fig. 10. Fig. 10 represents a relationship between a light level for full light and the detection voltage 106 of the discharge lamp 104 under normal condition, and another relationship between the light level for the full light and the reference voltage. When the light level for the full light is smaller than, or equal to a predetermined value, the hysteresis characteristics are established by the three-stage switching circuit 114 at the point where the reference voltage to be set the comparator 107 is switched from the first reference voltage 108a to the second reference voltage 108b and further from the second reference voltage 108b to the third reference voltage 108c, and at the point where the reference voltage is changed from the second reference voltage to the first reference voltage, as indicated in Fig. 10, and further from the second reference voltage 108b to the first reference voltage 108a. It should be noted that the reference voltage owns the necessary condition, i.e., the first reference voltage 108a < the second reference voltage 108b < the third reference voltage 108c. Then, when the detected voltage 106 reaches the first reference voltage 108b, or the third reference voltage 108c, it is judged that the discharge lamp 104 is in the final lifetime stage. Accordingly, the first reference voltage 108a, the second 108b, and the third reference voltage 108c are stably switched by the three-stage switching circuit 114, and the furthermore, it is possible to prevent the three-stage switching circuit 114 from being very sensitively reacted in response to the externally supplied noise. Also, the comparator 107 can perform such a correct judgment between the discharge lamp 104 under normal state and the discharge lamp 104 in the final lifetime stage over the entire range of the light level. As a consequence, the discharge lamp 104 can properly used, and also it is possible to prevent the discharge lamp igniting apparatus from being destroyed.

(Fourth Embodiment)

[0029] Fig. 11 is a diagram for explaining a discharge lamp igniting apparatus according to a further embodiment of the present invention. In Fig. 11, reference numeral 115 shows an amplifying circuit for amplifying the voltage 108a, and reference numeral 116 indicates an amplified voltage outputted from the amplifying circuit 115. it should be noted that the same reference numeral shown in the first to third embodiments are employed as those for indicating the same or similar circuit elements of the fourth embodiment.

[0030] Referring now to Fig. 11, a description will be made of a discharge lamp igniting apparatus according to the fourth embodiment. The dimming control signal 111 is inputted into the amplifying circuit 115, and the first reference voltage 108a is gradually amplified in response to the dimming control signal 111. The comparator 107 for constituting the control circuit llo compares the detected voltage 106 with the amplified voltage 116 outputted from the amplifying circuit 115. Then, when the detected voltage becomes high, the comparator 107 judges that the discharge lamp 104 is in the final lifetime stage, and thus the control circuit 110 sends out to the high frequency power supply 102, such a control signal 112 for interrupting, or reducing the output of the high frequency power supply 102 by way of the control circuit 110.

[0031] Also, the operations of the discharge lamp igniting apparatus will now be explained with employing a characteristic diagram shown in Fig. 12. Fig. 12 represents a relationship between a light level for the full light and the detected voltage 106 of the discharge lamp operated under normal condition, and further another relationship between the light level for the full light and the amplified reference voltage.

[0032] In connection with the changes from 100% to 0% in the light level for the full light, as indicated in Fig. 12, the reference voltage is gradually amplified in the amplifying circuit 115. Then, when the detected voltage 106 reaches the amplified voltage 116, it is so judged that the discharge lamp 104 is in the final lifetime period. Accordingly, the comparator 104 can correctly discriminate the discharge lamp 104 operated under normal condition from the discharge lamp 104 operated in the final lifetime stage over the entire region of the light level. As a consequence, the discharge lamp 104 can be used in the proper manner, and further it is possible to prevent the discharge lamp igniting apparatus from being electrically destroyed in advance.

(Fifth Embodiment)

[0033] Fig. 13 is a diagram for explaining a discharge lamp igniting apparatus according to a further embodiment of the present invention. In Fig. 13, reference numeral 119 shows a divided voltage obtained by dividing the reference voltage based on a first resistor 117 and a second resistor 118, and reference numeral 120 denotes a switch circuit operated in response to the dimming control signal 111. It should be noted that the same reference numerals shown in the first to fourth embodi-

ments are employed as those for indicating the same or similar circuit elements of the fifth embodiment.

[0034] Referring now to Fig. 13, a description will be made of a discharge lamp igniting apparatus according to the fifth embodiment. the dimming control signal 111 is inputted into the switch circuit 120, and when the light level is larger than, or equal to an arbitrarily set value, the switch circuit 120 is stopped, so that the detected voltage 106 is inputted into the comparator 107. Also, when the light level is smaller than, or equal to the arbitrarily set value, the switch circuit 120 is actuated. As a result, the detected voltage 106 is divided by the first resistor 117 and the second resistor 118, so that the divided voltage 119 is inputted into the comparator 107. The comparator 107 compares the detection voltage 106 with the first reference voltage 108a, or the divided voltage 119 with the first reference voltage 108a. Then, when the detected voltage becomes high, the comparator 107 judges that the discharge lamp 104 is in the final lifetime stage, and thus the control circuit 110 sends out to the high frequency power supply 2, such a control signal 112 for interrupting, or reducing the output of the high frequency power supply 102 by way of the control circuit 110.

[0035] also, the operations of the discharge lamp igniting apparatus will now be explained with employing a characteristic diagram shown in Fig. 14 fig. 14 represents a relationship between a light level for the full light and the detected voltage 106 of the discharge lamp 104 operated under normal condition, and further another relationship between the light level for the full light and the divided voltage. when the light level for the full light is larger than, or equal to a predetermined value, namely in a range where the switch circuit 120 is not operable, the detected voltage 106 of the discharge lamp 104 operated under normal condition is produced, as shown in Fig. 14. to the contrary, when the light level is smaller than, or equal to a predetermined value, namely, in a range where the switch circuit 120 is operable, since the detected voltage of the discharge lamp 104 operated under normal condition is subdivided, this detected voltage is decreased. Then, when the detected voltage 106, or the divided voltage 119 reaches the first reference voltage 118a, it is so judged that the discharge lamp 104 is in the final lifetime period. Accordingly, the comparator 104 can correctly discriminate the discharge lamp 104 operated from the discharge lamp 104 operated in the final lifetime stage over the entire region of the light level. As a consequence, the discharge lamp 104 can be used in the proper manner, and further it is possible to prevent the discharge lamp igniting apparatus from being electrically destroyed in advance.

(Sixth Embodiment)

[0036] Fig. 15 is a diagram for explaining a discharge lamp igniting apparatus according to a further embodiment of the present invention. In Fig. 15, reference numeral 121 shows an attenuator for attenuating the detecting voltage 106, and reference numeral 122 indicates an attenuated voltage attenuated by the attenuator 121. It should be noted that the same reference numerals shown in the first to fifth embodiments are employed as those for indicating the same or similar circuit elements of the sixth embodiment.

[0037] Referring now to Fig. 15, a description will be made of a discharge lamp igniting apparatus lamp igniting apparatus according to the sixth embodiment. the dimming control signal 111 is inputted into the attenuator 121, and the detected voltage 106 is gradually attenuated is response to the decrease of the light level. The comparator 107 compares the reference voltage 108a with the attenuated voltage 122 attenuated by the attenuator 121. Then, when the attenuated voltage 122 becomes high, the comparator 107 judges that the discharge lamp 104 is in the final lifetime stage, and thus the control circuit 110 sends out to the high frequency power supply 102, such a control signal 112 for interrupting, or reducing the output of the high frequency power supply 102 by way of the control circuit 110.

[0038] Also, the operation of the discharge lamp igniting apparatus will now be explained with empoying a characteristic diagram shown in Fig. 16. Fig. 16 represents a relationship between a light level for the full light and the detection voltage 106 of the discharge lamp 104 operated under normal condition, and further another relationship between the light level for the full light and the attenuated voltage produced by attenuating the detected voltage 6 of the discharge lamp 104 operated under normal condition. In connection with the changes from 100% to 0% in the light level for full light, as indicated in Fig. 16, the detected voltage 106 of the discharge lamp 104 operated under normal condition is gradually attenuated by the attenuator 121. then, when the attenuated voltage 122 reaches the first reference voltage 108a, it is so judged that the discharge lamp 104 is in the final lifetime period. Accordingly, the comparator 104 can correctly discriminate the discharge lamp 104 operated under normal condition from the discharge lamp 104 operated in the final lifetime stage over the entire region of the light level. As a consequence, the discharge lamp 104 can be used in the proper manner, and further it is possible to prevent the discharge lamp igniting apparatus from being electrically destroyed in advance.

(Seventh Embodiment)

[0039] Fig. 17 is a diagram for explaining a discharge lamp igniting apparatus to a further embodiment of the present invention. In Fig. 17, reference numeral 123 indicates a judging circuit for judging whether or not the control signal 112 is sent to the high frequency power supply 102 in response to the dimming control signal 11. It should be noted that the same reference numerals shown in the first to sixth embodiments are employed

as those for indicating the same or similar circuit elements of the seventh embodiment.

[0040] Referring now to Fig. 17, a description will be made of a discharge lamp igniting apparatus according to the seventh embodiment. The dimming control signal is inputted into the judging circuit 123, and when the light level of the discharge lamp 104 is larger than, or equal to a set value, and further the comparator 107 judges that the discharge lamp 104 is in the final lifetime period, the judging circuit 123 causes the control circuit 110 to send out the control signal 112 to the high frequency power supply 102, so that the output of the high frequency power supply 102 is interrupted, or reduced. In the case that the light level is smaller than, or equal to a predetermined value, even when the comparator 107 judges that the discharge lamp 104 is in the final lifetime period, the judging circuit 123 causes the control circuit 110 to sent out the control signal 112 to the high frequency power supply 102.

[0041] Also, the operations of the discharge lamp igniting apparatus will now be explained with employing a characteristic diagram shown in Fig. 18. Fig. 18 represents a relationship between light level for the full light and power consumption of the discharge lamp 104. When the light level for the full light is larger than, or equal to a predetermined value, if the discharge lamp 104 is in the final lifetime period, then such a protection operation for interrupting, or reducing the output of the high frequency power supply 102 is carried out by the judging circuit 123. However, when the light level is smaller than, or equal to a predetermined value, if the discharge lamp 104 is in the final lifetime period, then such a protection operation for interrupting, or reducing the output of the high frequency power supply 102 is stopped by the judging circuit 123. This may constitute an idea. That is, when the light level is low, even if the discharge lamp 104 is in the final lifetime period and thus a DC current will flow through the high frequency power supply 102, the power consumption is reduced. As a result, substantially no load is given to the high frequency power supply 102. Accordingly, even when such an arrangement is employed in the comparator 107 in which the first reference voltage 108a is set to a low value, and therefor the final lifetime period of the discharge lamp 104 is high sensitively judged, there is no erroneous judgement that when the light level is low, the discharge lamp 104 operated under normal operation is recognized as the discharge lamp 104 operated in the final lifetime stage. Thus, the discharge lamp 104 can be properly used.

[0042] As was described above, the present invention can obtain the following advantages.

[0043] The discharge lamp igniting apparatus according to the first aspect of the invention includes: voltage detecting means for detecting a voltage of the discharge lamp; voltage changing means for changing either the voltage of the discharge lamp detected by this voltage detecting means or a reference voltage in response to a light level of the discharge lamp; comparing means for comparing the reference voltage with the voltage of the discharge lamp changed by this voltage changing means; and control means for interrupting, or reducing the output of the high frequency power supply when the voltage of the discharge lamp becomes high. Accordingly, it is possible to more correctly discriminate the discharge lamp operated under normal condition from the discharge lamp operated in the final lifetime stage over the entire of the light level. As a consequence, there are such effects that the discharge lamp can be used in the proper manner, and further the electrical destroy of the discharge lamp igniting apparatus can be avoided in advance.

[0044] In the discharge lamp igniting apparatus according to second aspect of the invention, the control means employed in the first aspect of the invention included two-stage switching means for switching a first reference voltage and a second reference voltage when the light level of the discharge lamp is lower than, or equal to a predetermined value; the comparing means compares the voltage of the discharge lamp with the first reference voltage, or the voltage of the discharge lamp with the second reference voltage; and when the voltage of the discharge lamp becomes high, the output of the high frequency power supply is interrupted, or reduced. Accordingly, it is possible to more correctly discriminate the discharge lamp operated under normal condition from the discharge lamp operated in the final lifetime stage over the entire range of the light level. As a consequence, there are such effects that the discharge lamp can be used in the proper manner, and further the electrical destroy of the discharge lamp igniting apparatus can be avoided in advance.

[0045] In the discharge lamp igniting apparatus according to the third aspect of the invention, the control means employed in the first aspect of the invention includes two-stage switching means for switching a fist reference voltage and a second reference voltage when the light level of the discharge lamp is lower than, or equal to a predetermined value; the comparing means compares the voltage of the discharge lamp with the first reference voltage, or the voltage of the discharge lamp with the second reference voltage; and when the voltage of the discharge lamp becomes high, the output of the high frequency power supply is interrupted, or reduced. The first reference voltage and the second reference voltage are switched under stable condition. Further, it is possible to prevent the two-stage switching circuit from being very sensitively reacted in response to the externally supplied noise. Accordingly, it is possible to more correctly discriminate the discharge lamp operated under normal condition from the discharge lamp operated in the final lifetime stage over the entire range of the light level. As a consequence, there are such effects that the discharge lamp can be used in the proper manner, and further the electrical destroy of the discharge lamp igniting apparatus can be avoided in advance.

[0046] In the discharge lamp igniting apparatus according to the fourth aspect of the invention, the control means employed in the first aspect of the invention includes hysteresis means for establishing a hysteresis characteristic at a point where when the light level of the discharge lamp is smaller than or equal to a predetermined value, plural-stage switching means switches the voltage from the first reference voltage into the second reference voltage and further from the second reference voltage into a third reference voltage; and at another point where the plural-stage switching means switches the voltage from the third reference voltage to the second reference voltage and further from the second reference voltage to the first reference voltage; and the comparing means compares the voltage of the discharge lamp with the first reference voltage, or the voltage of the discharge lamp with the second reference voltage, or the voltage of the discharge lamp with the third reference voltage; and when the voltage of the discharge lamp becomes high the output of the high frequency power supply is interrupted or reduced. The first reference voltage, the second reference voltage and the third reference voltage are switched under stable condition. Further, it is possible to prevent the plural-stage switching circuit from being very sensitively reacted in response to the externally supplied noise. Accordingly, it is possible to more correctly discriminate the discharge lamp operated under normal condition from the discharge lamp operated in the final lifetime stage over the entire range to the light level as a consequence, there are such effects that the discharge lamp can be used in the proper manner, and further the electrical destroy of the discharge lamp igniting apparatus can be avoided in advance.

[0047] In the discharge lamp igniting apparatus according to the fifth aspect of the invention, the control means employed in the first aspect of the invention includes voltage amplifying means for gradually amplifying the reference voltage in connection with the decrease of the light level of the discharge lamp; the comparing means compares the voltage of the discharge lamp with the voltage amplified by the voltage amplifying means; and when the voltage of the discharge lamp becomes high, the output of the high the output of the high frequency power supply is interrupted or reduced. Accordingly, it is possible to more correctly discriminate the discharge lamp operated under normal condition from the discharge lamp operated in the final lifetime stage over the entire range of the light level. As a consequence, there are such effects that the discharge lamp can be used in the proper manner, and further the electrical destroy of the discharge lamp igniting apparatus can be avoided in advance.

[0048] In the discharge lamp igniting apparatus according to the sixth aspect of the invention, the control means employed in the first aspect of the invention includes voltage dividing means for dividing the voltage of the discharge lamp is smaller than, or equal to a predetermined value; the comparing means compares the voltage of the discharge lamp with the reference voltage, or the voltage divided by the voltage dividing means with the reference voltage; and when the voltage of the discharge lamp, or the voltage divided by the voltage dividing means becomes high, the output of the high frequency power supply is interrupted, or reduced. Accordingly, it is possible to more correctly discriminate the discharge lamp operated under normal condition from the discharge lamp operated in the final lifetime stage over the entire range of the light level, as a consequence, there are such effects that the discharge lamp can be used in the proper manner, and further the electrical destroy of the discharge lamp igniting apparatus can be avoided in advance.

[0049] In the discharge lamp igniting apparatus according to the seventh aspect of invention, the voltage control means employed in the first aspect of the invention includes voltage attenuating means for gradually attenuating the voltage of the discharge lamp in connection with the decrease of the light level of the discharge lamp; the comparing means compares the reference voltage with the voltage attenuated by the voltage attenuating means; and when the voltage attenuated by the voltage attenuating means becomes high, the output of the high frequency power supply is interrupted, or reduced, accordingly it is possible to more correctly discriminate the discharge lamp operated under normal condition from the discharge lamp operated in the final lifetime stage over the entire range of the light level. As a consequence, there are such effects that the discharge lamp can be used in the proper manner, and further the electrical destroy of the discharge lamp igniting apparatus can be avoided in advance.

[0050] In the discharge lamp igniting apparatus according to the eighth aspect of the invention, the control means employed in the first aspect of the invention causes the comparing means to compare the voltage of the discharge lamp with the reference voltage when the light level of the discharge lamp is larger than, or equal to a predetermined value, and either interrupts or reduces the output of the high frequency power supply when the voltage of the discharge lamp becomes high. There is no such an erroneous judgement that when the light level is low, the discharge lamp operated under normal condition is judged as the discharge lamp operated in the final lifetime period. As a consequence, there is an effect that the discharge lamp can be utilized in a proper manner.

Claims

1. A discharge lamp igniting apparatus including a discharge lamp; and a high frequency power supply for supplying high frequency power to this discharge lamp, for controlling an output of this high frequency power supply to control light of said dis-

charge lamp, comprising:

voltage detecting means for detecting a voltage of said discharge lamp;

voltage changing means for changing either the voltage of said discharge lamp detected by this voltage detecting means or a reference voltage in response to a light level of said discharge lamp;

comparing means for comparing said reference voltage with the voltage of said discharge lamp changed by this voltage changing means; and

control means for interrupting, or reducing the output of said high frequency power supply when the voltage of the said discharge lamp becomes high.

2. A discharge lamp igniting apparatus as claimed in claim 1 wherein:
said control means includes two-stage switching means for switching a first reference voltage and a second reference voltage when the light level of said discharge lamp is lower than, or equal to a predetermined value; said comparing means compares the voltage of said discharge lamp with said first reference voltage, or the voltage of said discharge lamp with said second reference voltage; and when the voltage of said discharge lamp becomes high, the output of said high frequency power supply is interrupted, or reduced.

3. A discharge lamp igniting apparatus as claimed in claim 1 wherein:
said control means includes hysteresis means for establishing a hysteresis characteristic at a point where when the light level of said discharge lamp is smaller than, or equal to a predetermined value, the first reference voltage is switched into the second reference voltage by said two-stage switching means, and at another point where said second reference voltage is switched into said first reference voltage by said two-stage switching means; said comparing means compares the voltage of said discharge lamp with said first reference voltage, or the voltage of said discharge lamp with said second reference voltage; and when the voltage of said discharge lamp becomes high, the output of said high frequency power supply is interrupted, or reduced.

4. A discharge lamp igniting apparatus as claimed in claim 1 wherein:
said control means includes hysteresis means for establishing a hysteresis characteristic at a point where when the light level of said discharge lamp is smaller than, or equal to a predetermined value, plural-stage switching means switches the voltage from said first reference voltage into said second reference voltage and further from said second reference voltage into a third reference voltage; and at another point where the plural-stage switching means switches the voltage from said third reference voltage to the second reference voltage and further from said second reference voltage to said first reference voltage; and said comparing means compares the voltage of said discharge lamp with said first reference voltage, or the voltage of said discharge lamp with said second reference voltage, or the voltage of said discharge lamp with said third reference voltage; and when the voltage of said discharge lamp becomes high, the output of said high frequency power supply is interrupted, or reduced.

5. A discharge lamp igniting apparatus as claimed in claim 1 wherein:
said control means includes voltage amplifying means for gradually amplifying said reference voltage in connection with the decrease of the light level of said discharge lamp; said comparing means compares the voltage of said discharge lamp with the voltage amplified by said voltage amplifying means; and when the voltage of said discharge lamp becomes high, the output of said high frequency power supply is interrupted, or reduced.

6. A discharge lamp igniting apparatus as claimed in claim 1 wherein:
said control means includes voltage dividing means for dividing the voltage of said discharge lamp when the light level of said discharge lamp is smaller than, or equal to a predetermined value; said comparing means compares the voltage of said discharge lamp with said reference voltage, or the voltage divided by said voltage means with said reference voltage; and when the voltage of said discharge lamp, or the voltage divided by said voltage dividing means becomes high, the output of said high frequency power supply is interrupted, or reduced.

7. A discharge lamp igniting apparatus as claimed in claim 1 wherein:
said voltage control means includes voltage attenuating means for gradually attenuating the voltage of said discharge lamp in connection with the decrease of the light level of said discharge lamp; said comparing means compares said reference voltage attenuated by said voltage attenuating means; and when the voltage attenuated by said voltage attenuating means become high, the output of said high frequency power supply is interrupted, or reduced.

8. A discharge lamp igniting apparatus as claimed in claim 1 wherein:
said control means causes said comparing means

to compare the voltage of said discharge lamp with said reference voltage when the light level of said discharge lamp is larger than, or equal to a predetermined value, and either interrupts or reduces the output of said high frequency power supply when the voltage of said discharge lamp becomes high.

FIG. 1
PRIOR ART

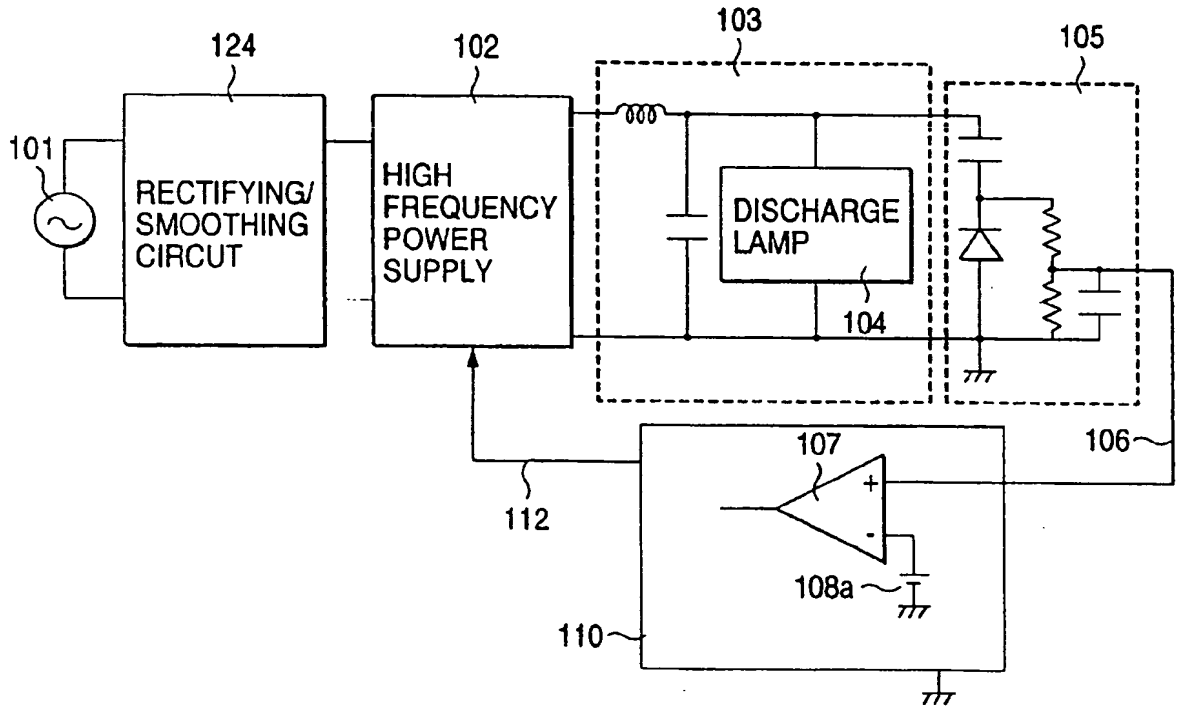


FIG. 2
PRIOR ART

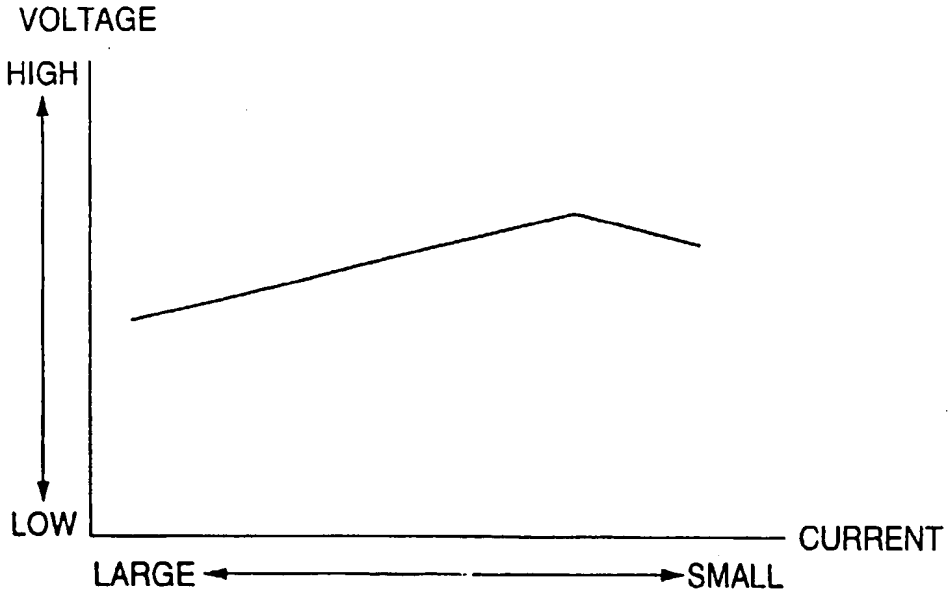


FIG. 3
PRIOR ART

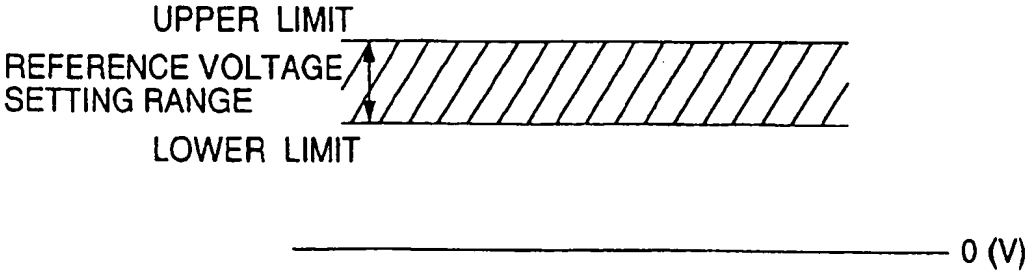


FIG. 4
PRIOR ART

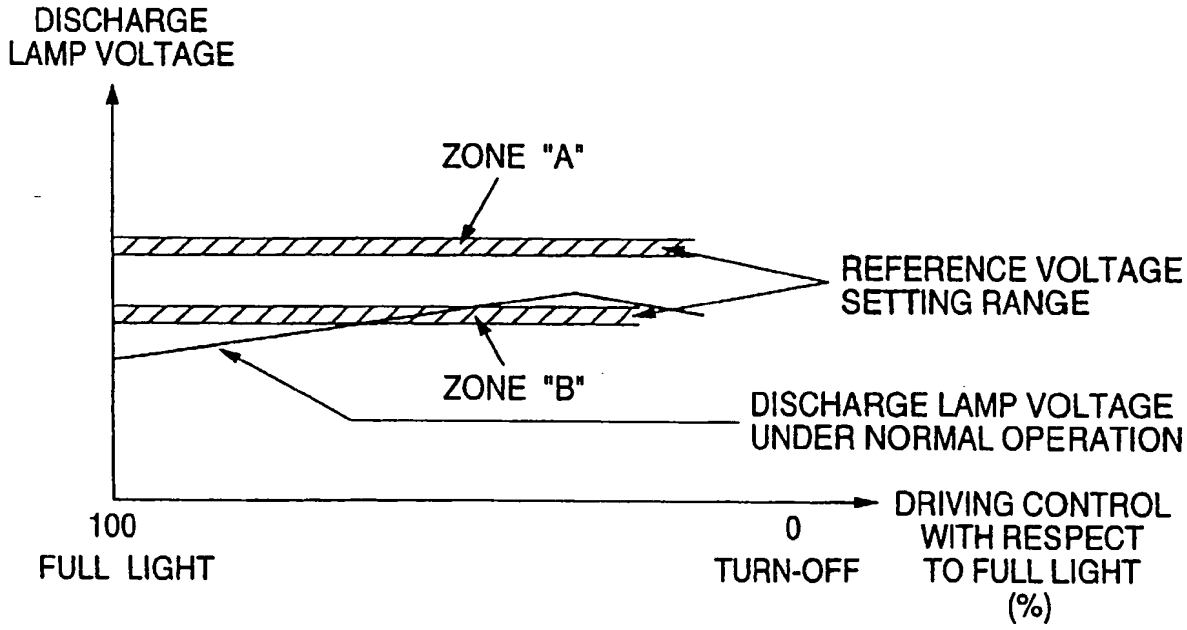


FIG. 5

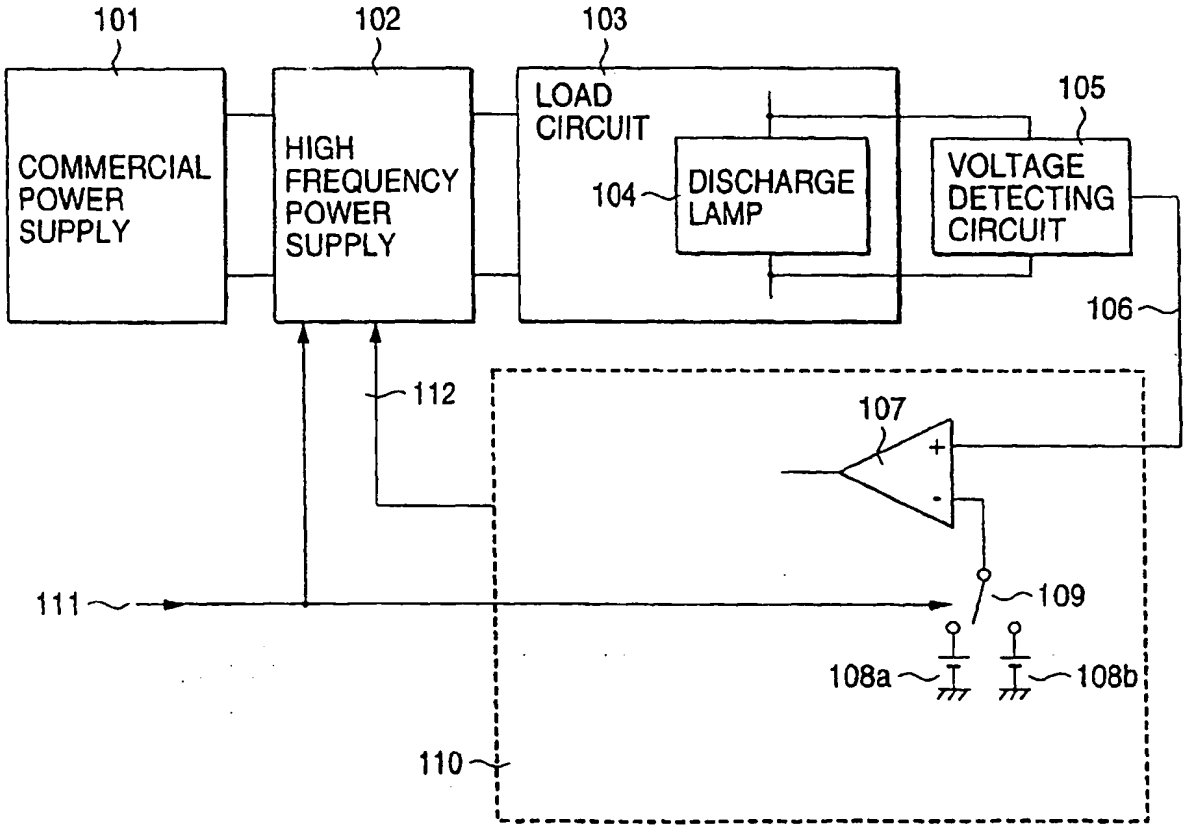


FIG. 6

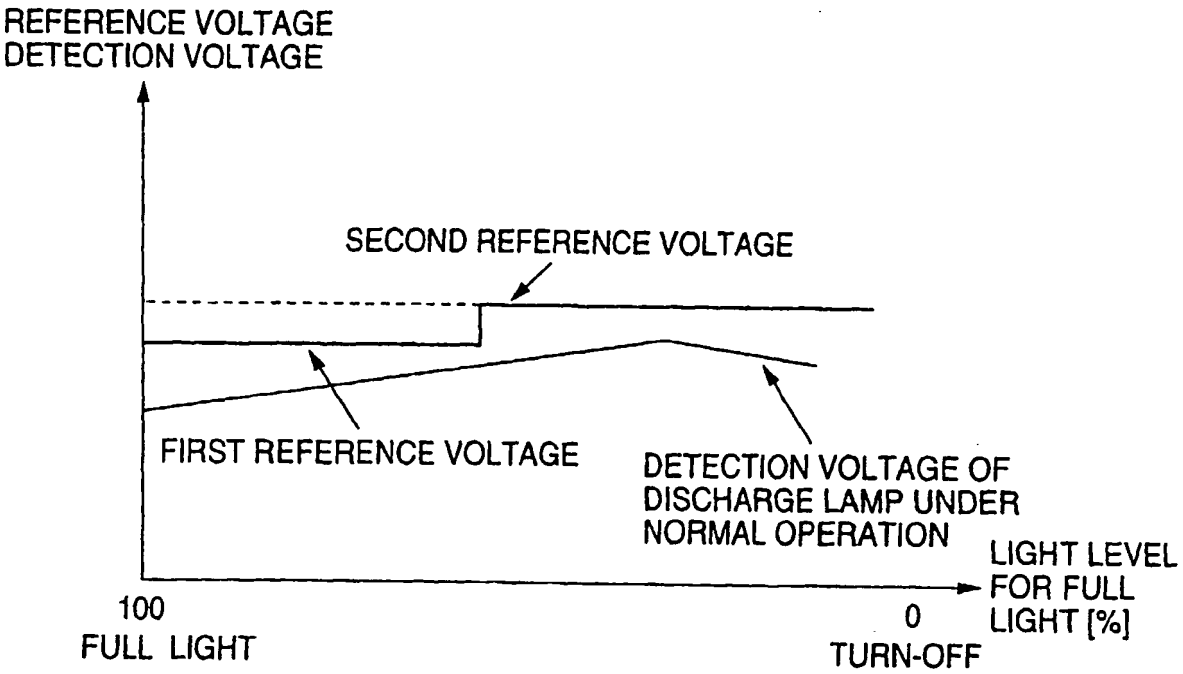


FIG. 7

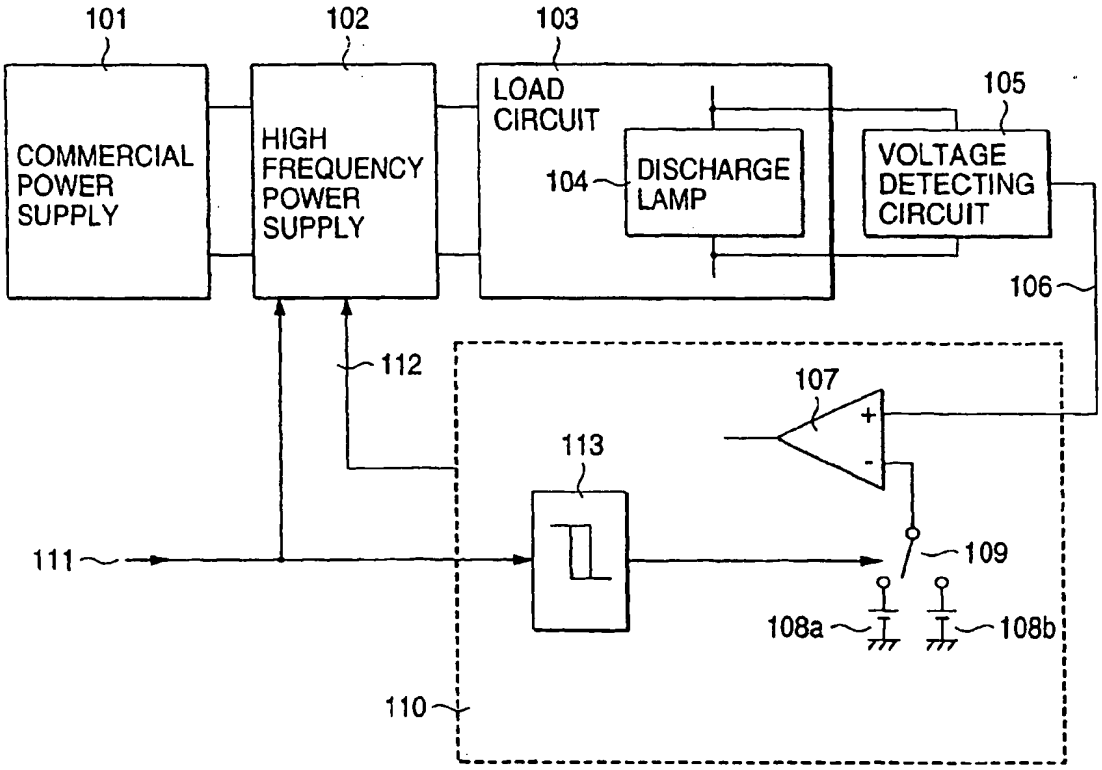


FIG. 8

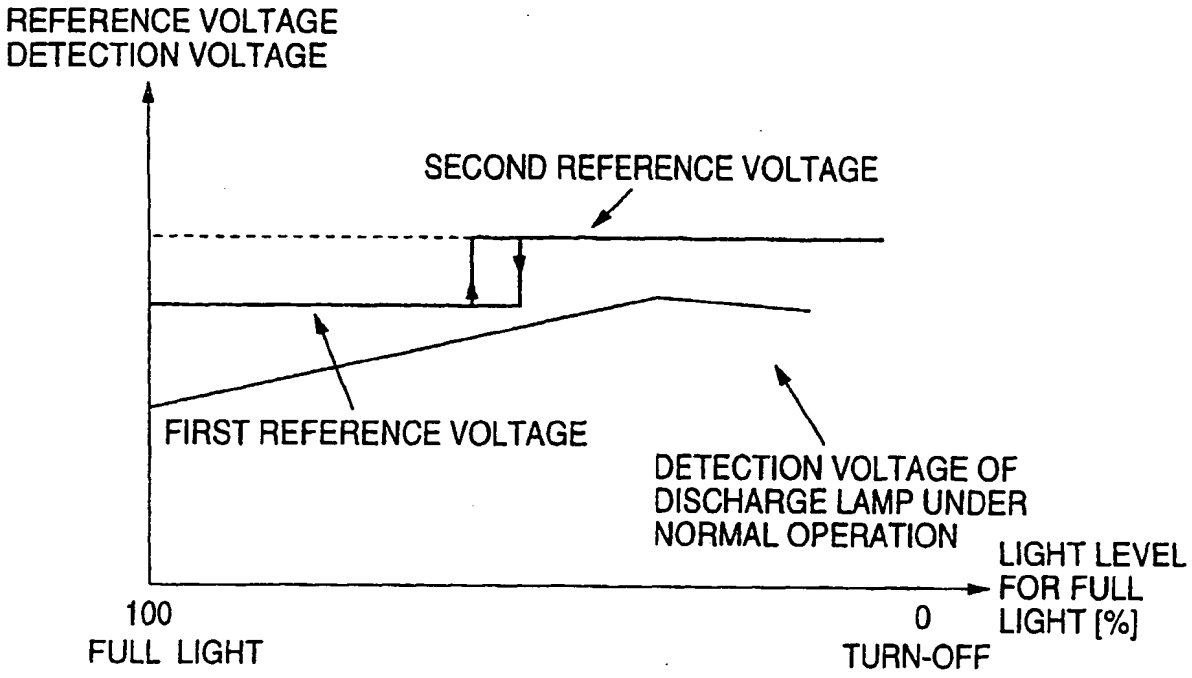


FIG. 9

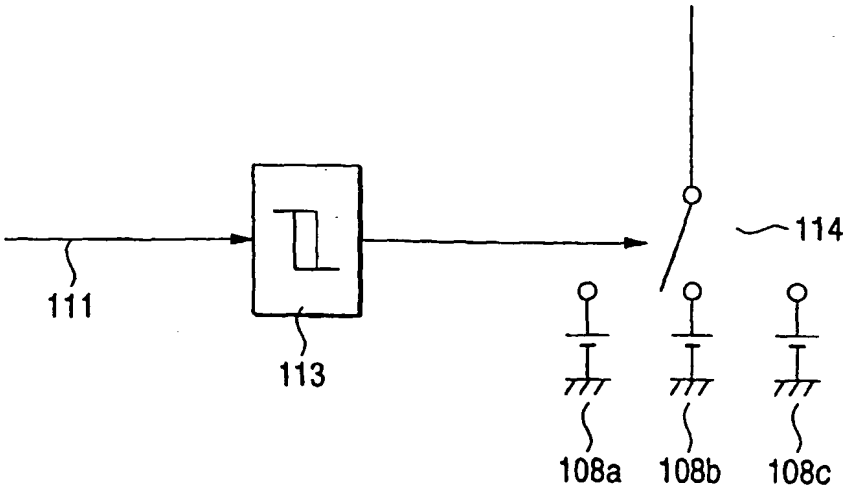


FIG. 10

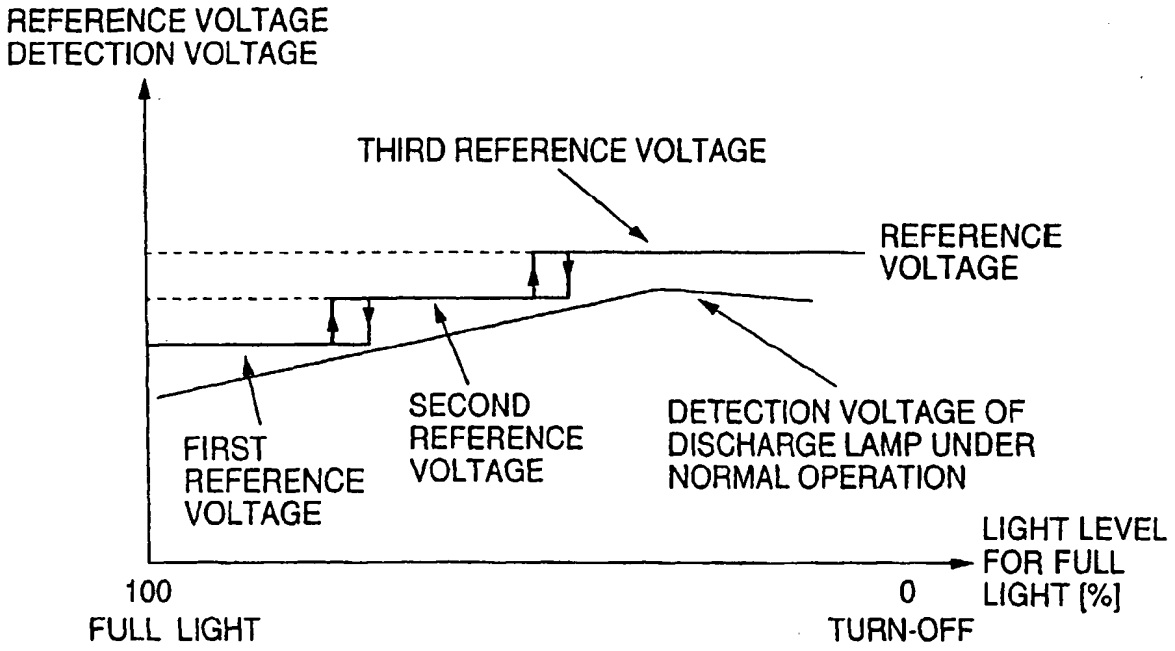


FIG. 11

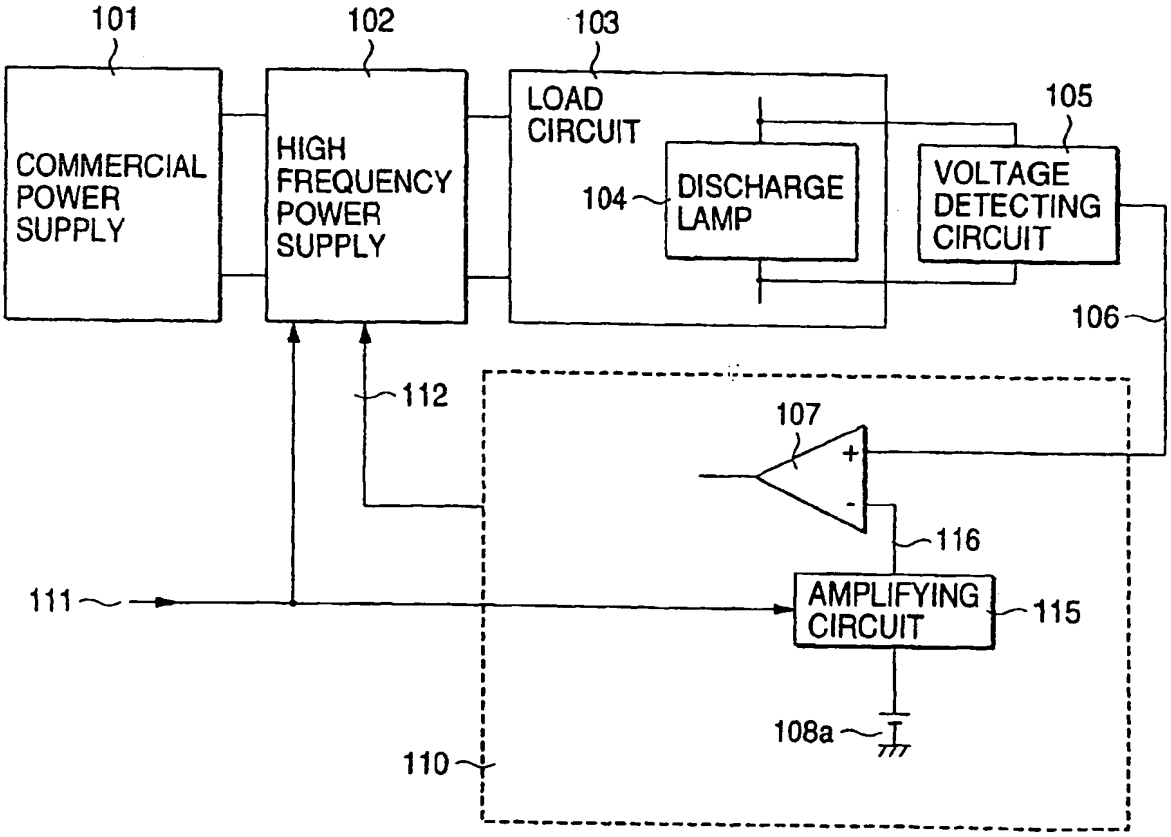


FIG. 12

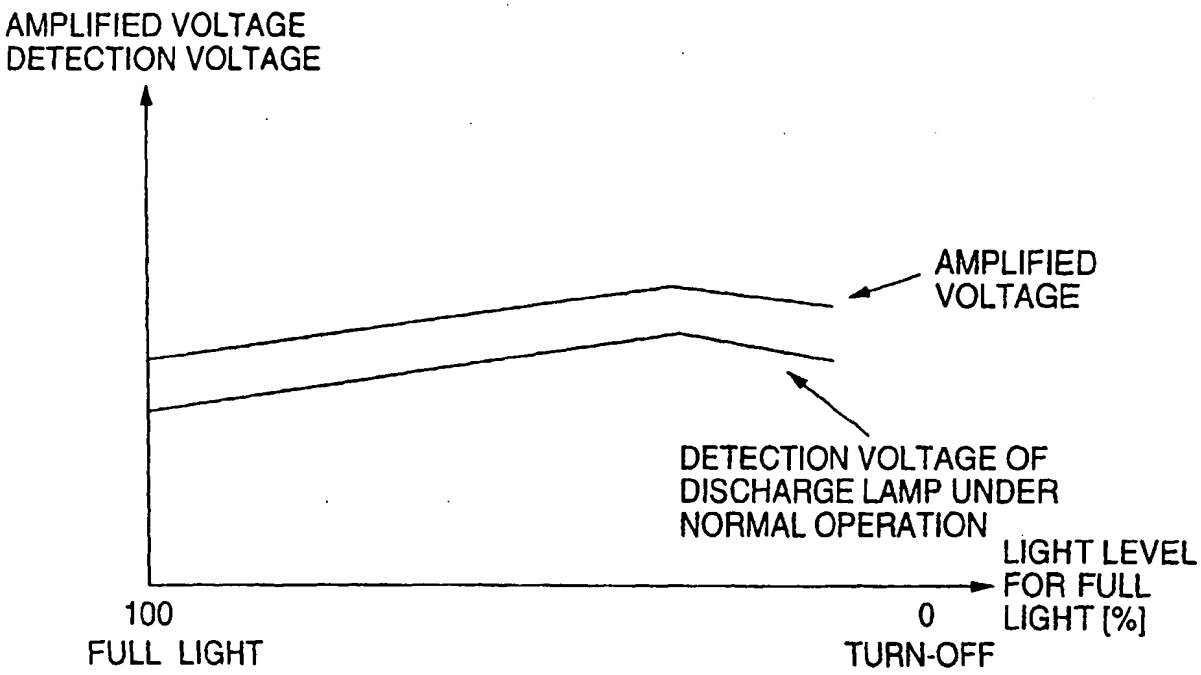


FIG. 13

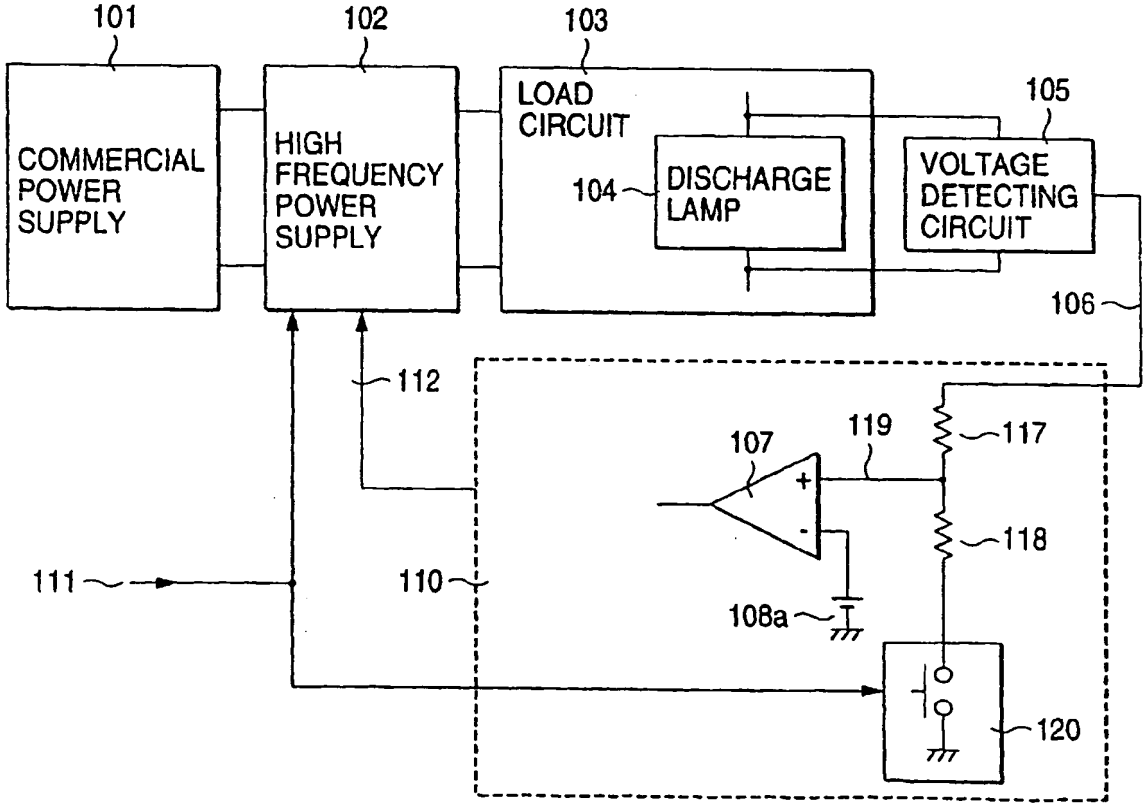


FIG. 14

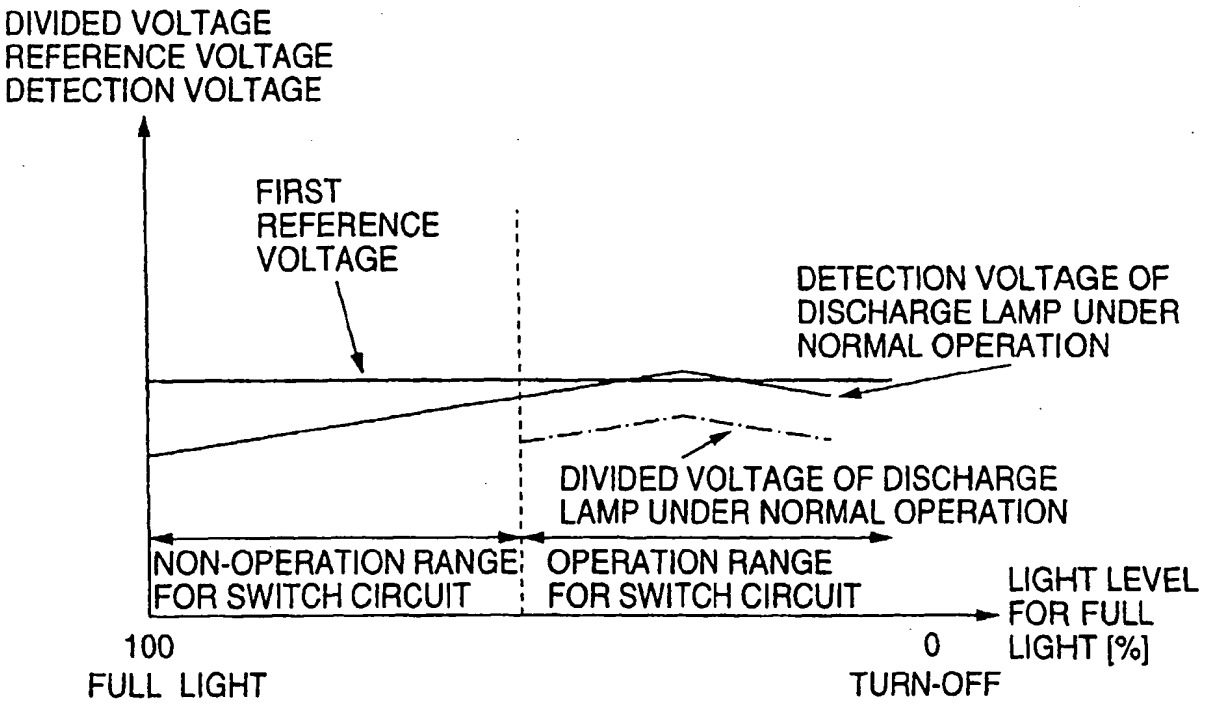


FIG. 15

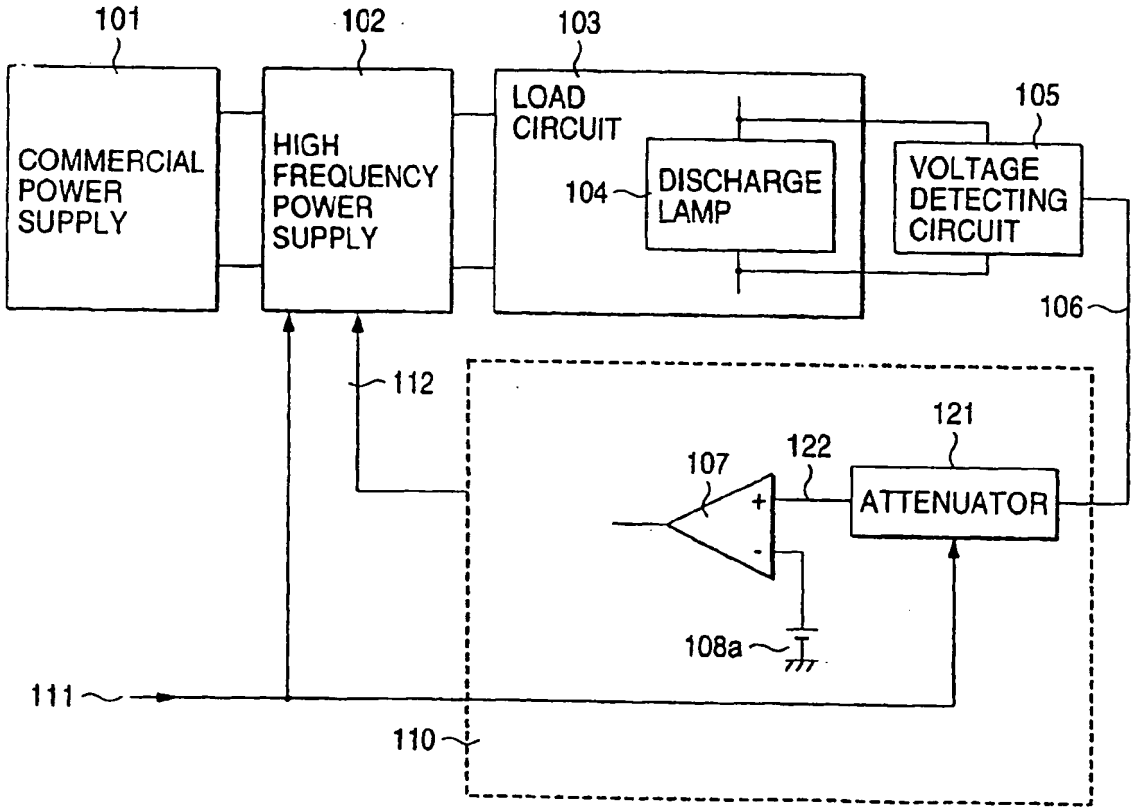


FIG. 16

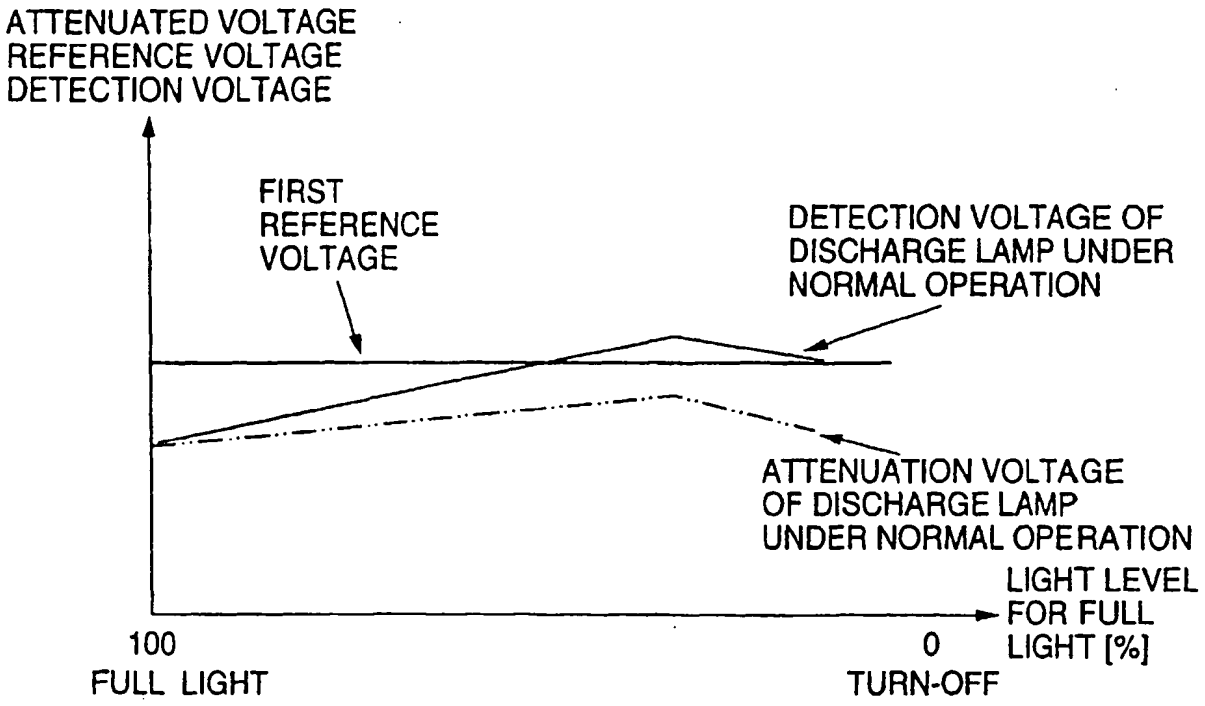


FIG. 17

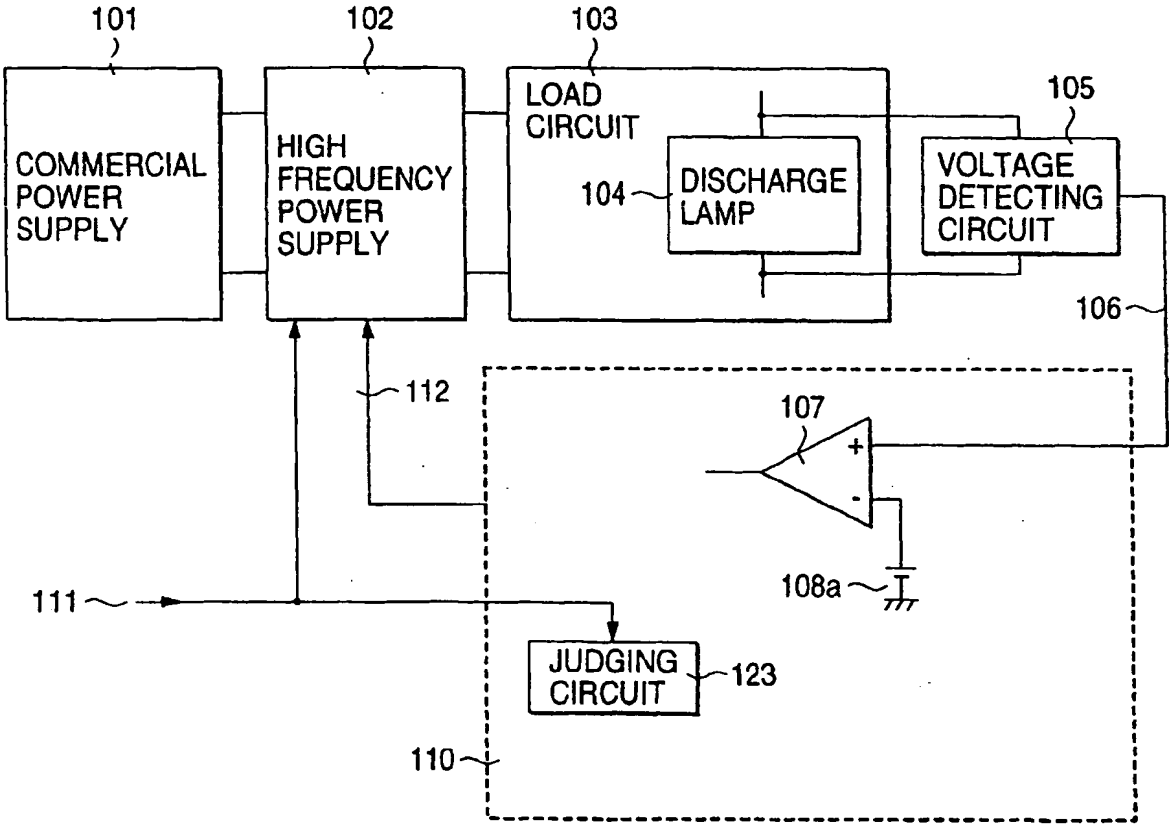
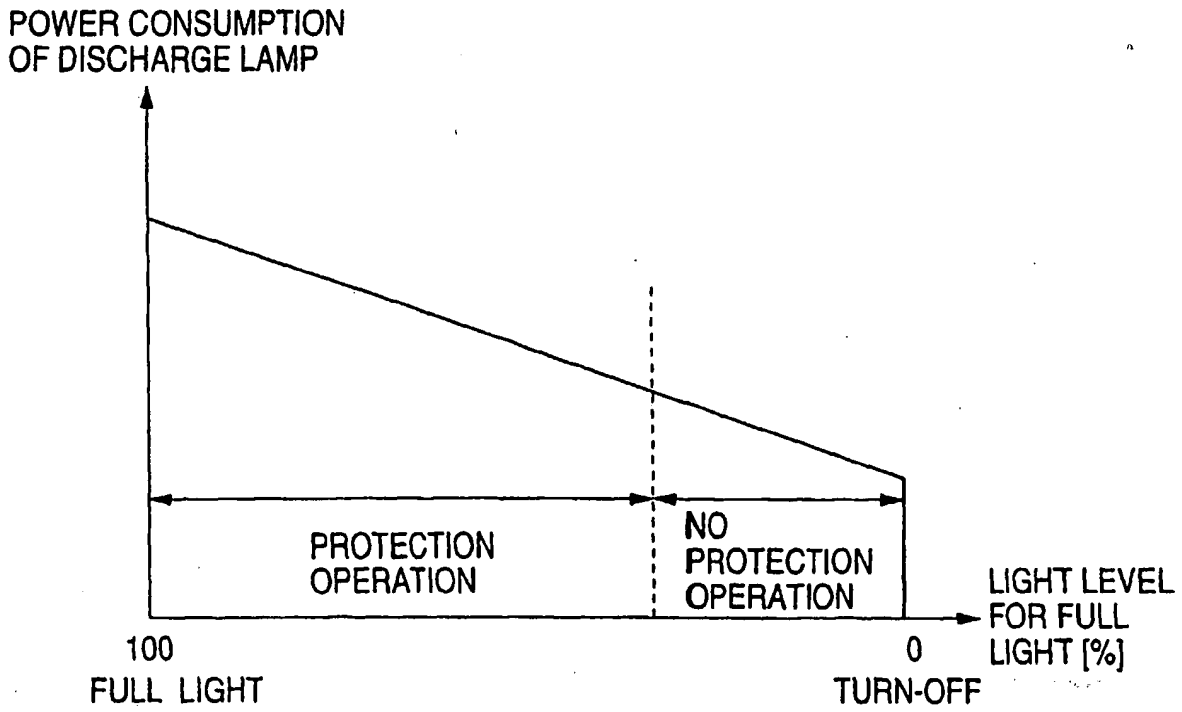


FIG. 18


POWER CONSUMPTION
OF DISCHARGE LAMP
PROTECTION
OPERATION
NO
PROTECTION
OPERATION
LIGHT LEVEL
FOR FULL
LIGHT [%]
100
FULL LIGHT
0
TURN-OFF